

# **The role of decision-making parameters in constructing and re-engineering of distribution networks**

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*Distribution networks have to interconnect the consumption and production sides of the supply chain. Decision making has special parameters according to perspectives related to strategic, tactical and operational levels. Solving the cost vs. response trade-off has led to the construction of different types of distribution networks. On the other hand, the same product could be distributed across different networks - in modern logistics the competition is stronger between the contender supply chains than between the individual products. The identification and analysis of decision-making parameters at all levels are recommended in order to form the best construction and re-engineering strategies for a given distribution network.*

*Keywords: decision-making, distribution network, re-engineering*

## **1 Decision fields in distribution**

Distribution refers to the steps taken to move and store a product from the supplier stage to a customer stage in the supply chain [1]. Distribution is a key driver of the overall profitability of a firm because it directly impacts both the

supply chain cost and the customer experience. Good distribution can be used to achieve a variety of supply chain objectives ranging from low cost to high responsiveness. As a result, companies in the same industry often select very different distribution networks. Firms that target customers who can tolerate a large response time require few locations that may be far from the customer and can focus on increasing the capacity of each location. On the other hand, firms that target customers who value short response times need to locate close to them. These firms must have many facilities, with each location having a low capacity. Thus, a decrease in the response time customers desire increases the number of facilities required in the network. Changing the distribution network design affects the following supply chain costs: (1) inventories, (2) transportation, (3) facilities and handling, (4) information. Total logistics costs are the sum of inventory, transportation, and facility costs for a supply chain network. As the number of facilities is increased, total logistics costs first decrease and then increase. As a firm wants to further reduce the response time to its customers, it may have to increase the number of facilities beyond the point that minimizes logistics costs. A firm should add facilities beyond the cost-minimizing point only if managers are confident that the increase in revenues because of better responsiveness is greater than the increase in costs because of the additional facilities.

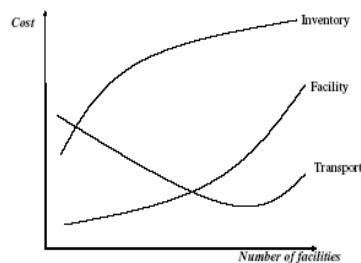


Figure 1

Main components of logistic cost [1]

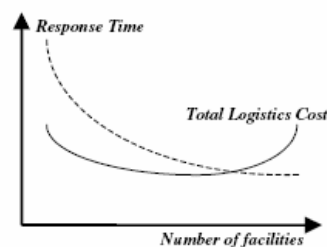


Figure 2

Total logistics cost and response time [1]

While strategic decisions determines the base parameters of the distribution network for long time perspectives (the topology design of the network, the capacity in warehouses, the critical distances, etc.), operational decisions mostly relates to daily plans. After a strategic investments provided decisions at the tactical level is requested to match the operational field near the possible optimal point of a given distribution system. Tactical decisions gives the mid-term

perspectives: development of an ideal fleet, changing the routes or batch sizes, outsourcing and other techniques, which are easy to apply for re-engineering.

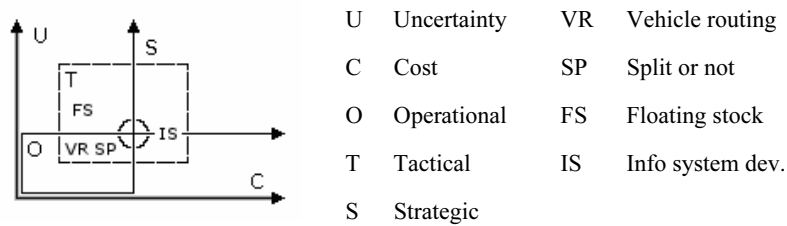
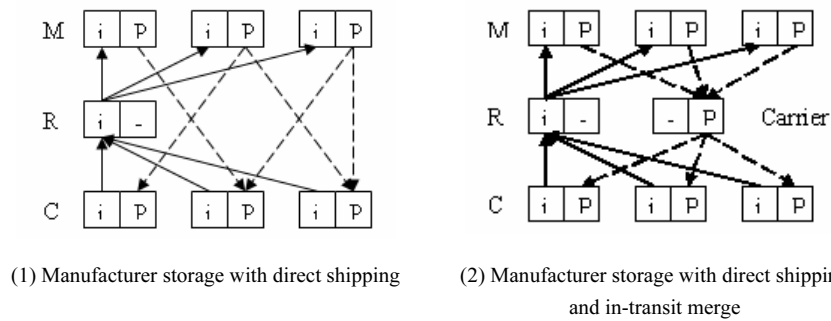


Figure 3  
STOP (Strategy-Tactic-Operation Paradigm)

In tactical decision making the first step is to identify the area for tactical decisions in the cost vs. uncertainties field, which is possible in the knowledge of exact or conditional parameters of daily operation and strategic visions.

## 2 Network topology - strategy and operation

There are different distinct distribution network designs related to the location of the delivery and the place of warehouses [1]. Most companies are best served by a combination of delivery networks. The combination used will depend upon product characteristics as well as the strategic position that the firm is targeting.



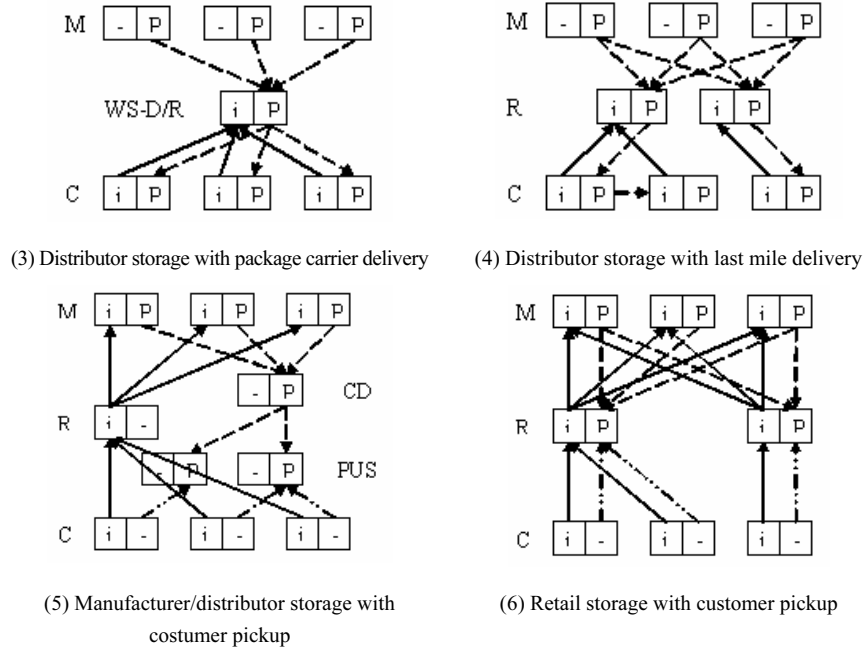


Figure 4. Network topology [based on source 1]

M: manufacturer, R: retailer, C: customer, WS: warehouse storage

continous arrow: information flow, jerky arrow: product flow, point-line arrow: customer flow

	Retail storage with customer pickup	Manufacturer storage with direct shipping	Manufacturer storage with in-transit merge	Distributor storage with package carrier delivery	Distributor storage with last mile de- livery	Manufacturer storage with pickup
Response time	1	4	4	3	2	4
Product variety	4	1	1	2	3	1
Product availability	4	1	1	2	3	1
Customer experience	5	4	3	2	1	5
Order visibility	1	5	4	3	2	6
Returnability	1	5	5	4	3	2
Inventory	4	1	1	2	3	1
Transportation	1	4	3	2	5	1
Facility and handling	6	1	2	3	4	5
Information	1	4	4	3	2	5

Figure 5. Comparative performance of delivery network design (1 indicates the best performance) [1]

	Retail storage with customer pickup	Manufacturer storage with direct shipping	Manufacturer storage with in-transit merge	Distributor storage with package carrier delivery	Distributor storage with last mile delivery	Manufacturer storage with pickup
High demand product	++	--	-	+-	+	-
Medium demand product	+	-	+-	+	+-	+-
Low demand product	-	+	+-	+	-	+
Very low demand product	--	++	+	+-	--	+
Many product sources	+	-	-	++	+	+-
High product value	-	++	+	+	+-	++
Quick desired response	++	--	--	-	+	--
High product variety	-	++	+-	+	+-	++
Low customer effort	--	+	++	++	++	-

++: Very suitable; +: somewhat suitable; +-: neutral; -: somewhat unsuitable; --: very unsuitable.

Figure 6. Performance of delivery networks for different product/customer characteristics [1]

### 3 The field of tactical concepts

#### 3.1 Vehicle routing

Reducing distribution costs has become an increasingly important challenge for many companies, especially in retail distribution, where a company's competitive position can depend on its ability to do so effectively and where each percent of savings can represent huge costs [2]. In retail, margins are low, volumes are high and geographic coverage is large. Regardless of whether stores are franchises, independently owned or owned by the parent company, a certain level of customer service is crucial to the good operation of the company as a whole. Therefore retailing companies face the challenge of finding a balance between distribution costs and customer service, where vehicle routing is critical. Two groups of algorithms commonly used for solving load building and routing problems are vehicle routing heuristics and continuous approximation approaches. Continuous approximation methods detailed by Daganzo can be used to solve load building and routing problems. However, this method requires that the cost between two stores be a function of their location in two-dimensional space, which is not the case in a hub-and-spoke network. Hall combines bin packing and vehicle routing to solve a distribution problem. He notes that the cost to send a group of shipments from one origin to multiple destinations depends on two factors: (1) the number of loads built, and (2) the average length of the routes (distance). With the use of continuous approximation techniques Hall constructs an algorithm called "best-fit-save-V" that divides the total region into zones and builds the loads for several destinations simultaneously. He concludes that the best balance between the

number of loads and the average length of the routes is a function of the square root of the size of the regions and of the average distance between the origin and the destinations, where destinations are distributed uniformly within the region. In Hall's algorithm, any store can be loaded with any other store in the same region. If the region size was reduced until any store can be loaded with any other in the region, there would no longer exist enough combinations to fill the vehicles, given that a store's orders cannot be divided between several vehicles. Also, the fact that central stores can be assigned to any vehicle at little extra cost, but that the same is not true for outer lying stores, would not be taken into account.

### **3.2 Split or not**

In distribution problems, a fleet of vehicles serves the demand of a set of customers. Each customer is typically served by a single vehicle. However, more cost effective distribution plans may exist if some customers are served by more than one vehicle, i.e., if some deliveries are split [3]. It is possible to characterize distribution environments in which allowing split deliveries is likely to be beneficial. The delivery cost reductions obtained when allowing split deliveries appear to be due primarily to the ability to reduce the number of delivery routes. A reduction in the number of delivery routes may have additional cost benefits, as a smaller vehicle fleet is required. The largest benefits are obtained when the mean demand is greater than half the vehicle capacity but less than three quarters of the vehicle capacity and the demand variance is relatively small. The benefits from allowing split deliveries mainly depends on the relation between mean demand and vehicle capacity and on demand variance, there does not appear to be a dependence on customer locations.

### **3.3 Floating stocks**

The floating stock distribution concept [4] exploits intermodal transport to deploy. In this way response times are reduced and storage costs can be reduced as well by having products in the pipeline - it could be intended to ship before demand realization. The idea is that by advanced deployment and carefully tuning demand with transport modes, we can reduce nonmoving inventories, shorten lead times and improve the order fill rate. This strategy benefits from floating of stocks and the existence of intermodal terminals to postpone the selection of the destination so that a pooling effect can be obtained in comparison to direct road transport.

Fast delivery is used in many retail supply chains. The advantages are enjoyed mainly by the retailers as they can operate in a just-in-time mode: they need

fewer inventories on-site which reduces operational costs (both holding and storage costs) and investment costs (through less warehouse space required). When they call orders, they can rely on rapid fulfillment. This works well if the order lead times and production time allow the manufacturer to operate on a make-to-order basis. If this option is not available and substantial batches are made, the burden of keeping inventory is shifted from the retailer to the supplier. In this case, the supplier has to store it close to the retailer or use fast transport in order to meet the required order lead time. This leads to many transport movements with few opportunities for loaded return trips.

Considering the case of stochastic demand, it has been shown that the quantity-based policy has substantial saving over the time-based policy. Under a time-based policy, each order is dispatched by a pre-specified shipment release date, even though the dispatch quantity does not necessarily realize transportation scale economies. On the other hand, under a quantity-based policy, the dispatch quantity assures transportation scale economies, but a specific dispatch time cannot be guaranteed. An alternative to these two policies is a hybrid routine aimed at balancing the trade-off between the timely delivery advantages of time-based policies and the transportation cost savings associated with quantity-based policies. Under a hybrid policy, the objective is to consolidate an economic dispatch quantity.

### **3.4 Information system**

The initiatives in supply chain management based on new IT technologies and information sharing (IS) alongside the supply chain include collaborative planning, forecasting, and replenishment (CPFR), vendor-managed inventory (VMI), continuous replenishment programs (CRP), and efficient consumer response (ECR). The result has been changes in industrial structures and improvements in firm performance, but the benefits are not consistently distributed between retailers and manufacturers [5]. Firms have been able to reengineer their supply chains through real-time information sharing, enabled by electronic commerce technologies, such as electronic data interchange (EDI) and the Internet. Using CRP, buyers and suppliers share inventory status information so that they can increase replenishment frequencies and reduce inventory for both firms. With VMI, suppliers are authorized to manage inventories at buyers' locations and can rationalize inventory in the supply chain.

Information sharing (IS) is a collaborative program in which the downstream firm (referred to as a retailer herein) agrees to provide demand and inventory status in real time to the upstream firm (referred to as a manufacturer herein). In this case, the manufacturer no longer observes consumer demand through the retailer's order quantities but determines it directly from end consumers, though

the manufacturer still receives orders from the retailer (i.e., the retailer is responsible for placing orders). Both CRP and VMI provide closer collaboration between the manufacturer and the retailer. In addition to information sharing, CRP requires the manufacturer to implement a continuous replenishment process with the retailer; that is, increase the frequency of replenishments. In contrast, VMI is defined as collaboration between a manufacturer and a retailer, such that the manufacturer is authorized to manage the inventory at retail locations (in addition to information sharing and more frequent replenishments). The difference between CRP and VMI is that with VMI, the retailer no longer places orders with the manufacturer, but the manufacturer makes ordering decisions on behalf of the retailer on the basis of the shared information received from the retailer.

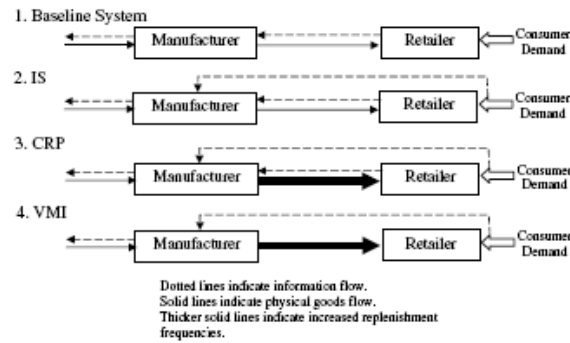


Figure 7. The possible roles of information sharing [5]

## Conclusions

A network designer needs to consider product characteristics as well as network requirements when deciding on the appropriate delivery network. The various networks have different strengths and weaknesses. It is difficult to design a distribution system flexible enough to follow changing demand - such seasons, campaigns, often unpredictable peaks – both on the supply and the consumption side. Depending on the operating strategy, there are waiting cycles at different points in the system – the consumer waits for the product, or the product waits for somebody, who will buy it. The skew (asimmetry) embodies critical factors in inventories (capacity, density) and transport features also (driving speed, batch size, unit size). The material flow is often associated with commercial activities, which could mean additional cost factors.

Decide the strategy questions belongs to the highest level of the management, contains several additional factors above the predicted distribution demands, based on the vision and mission of a company. In the field of strategic questions we have to choose from necessary investments into: (1) Warehouses (unit size, density from manufacturer to customer), (2) Fleets (unit size, time frequency,



delivery date), (3) Information technologies (integrated informatics system, equipments, devices, tracking infrastructure), etc. At the case of re-engineering, we should change these elements means add new warehouses, vehicles, info tech, etc. The competitive factors are network topology, characteristics of sources, drains, and the network elements, product features (critical conditions, restrictions) and batch size.

Operational decisions belongs to daily practice, manage the resources at an acceptable level and performance, which is always a trade-off between parameters, today already supported by smart software modules. Operational targets could be the optimization (1) for driving time, (2) for the effective use of the individual vehicles and the whole fleet, (3) for minimization of the distances and vehicle performance between stages, (4) for minimization of the cost, (5) for act upon calling hours, and (6) for acceptable shortages.

The nature of tactic decisions (where parameters in uncertainties and cost are between the strategy and operation levels) promise the most fruitful areas for further research work: defining and analysing the tactical fields and innovative tools (IS, FS, VMI, etc.) in different distribution systems.

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